DEPARTMENT OF
FISH, WILDLIFE AND PARKS

STREAM HABITAT INVENTORY PROCEDURES

Fisheries Research and Special Projects Bureau

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P.O. Box 67
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PLEASE RETURN

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LIST OF FIGURES

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INTRODUCTION

The stream habitat inventory methodology described in this report resulted from four years of study on tributaries to the North and Middle Forks of the Flathead River. This study was funded by the Environmental Protection Agency through the Flathead River Basin Steering Committee. The methodology draws upon multidisciplinary knowledge in describing the biological and physical features interacting to form the stream environment.

The basis for this methodology was the system developed by the Resource Analysis Branch of the British Columbia Ministry of the Environment and used to survey the Canadian portion of the North Fork drainage (Chamberlin 1980a, 1980b). During the four years of study, the method was refined to fit our specific needs and to reduce individual observer bias.

The U.S. Forest Service developed a Stream Reach Inventory and Channel Stability Evaluation technique (Figure 1) to identify unstable stream channel areas and to monitor recovery rates of such areas (U.S. Forest Service 1975). The channel stability method was incorporated into our habitat evaluation technique during the 1980 field season (Fraley et al. 1981) to provide comparable data between agencies. A detailed instruction booklet describing evaluation procedures is available from the U.S. Department of Agriculture, Forest Service Northern Region.

A line transect methodology similar to that described by Herrington and Dunham (1967) was included in 1982 to provide more precise site specific information.

Annual reports (Graham et al. 1980, Fraley et al. 1981, Shepard et al. 1982) should be consulted to determine exact methodologies used during each field season. Our modification of the original inventory glossary is presented in Appendix A.

METHODS

AERIAL SURVEY

The habitat evaluation process began by obtaining U.S. Geologic Survey Quadrangle maps (7.5 minute series) of the study area and color coding all tributaries to indicate stream order. Beginning at the mouth, each tributary was divided into one km sections on maps to facilitate the location of reach boundaries, survey sites and important stream features. Aerial photographs of the area were reviewed for landmark reference during aerial surveys.

Each tributary to be surveyed was flown by helicopter from its mouth to the upstream limit of suitable fish habitat. Suitable fish habitat was defined as perennial flow or adequate size to support a fish population. A definite fish barrier also marked the upstream boundary of the survey. During this upstream flight, important stream features such as slumped banks, obstructions to fish passage, beaver activity, trails and other

R-1 STREAM REACH INVENTORY and CHANNEL STABILITY EVALUATION

REACH LOCATION: Survey Date_____ T1ss_____ Obs._____

Forest_____ Rgr. Dist._____

F.W.I.

Stream_____ W/S No._____

Reach Description &

Other Identification_____

	Key #	Stability Indicators by Classes EXCELLENT		Fair and Poor on reverse side(s) GOOD	
Upper Banks	1	Bank slope gradient < 30%.	(2)	Bank slope gradient 30-40%.	(4)
	2	No evidence of past or any potential for future mass wasting into channel.	(3)	Infrequent and/or very small. Mostly healed over. Low future potential.	(6)
	3	Essentially absent from immediate channel area.	(2)	Present but mostly small twigs and limbs.	(4)
	4	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	(3)	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	(6)
	5	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	(1)	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	(2)
Lower Banks	6	65%+ with large, angular boulders 12"+ numerous.	(2)	40 to 65%, mostly small boulders to cobbles 6-12".	(4)
	7	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	(2)	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	(4)
	8	Little or none evident. Infrequent raw banks less than 6" high generally.	(4)	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	(6)
	9	Little or no enlargement of channel or point bars.	(4)	Some new increase in bar formation, mostly from coarse gravels.	(8)
Bottom	10	Sharp edges and corners, plane surfaces roughened.	(1)	Rounded corners and edges, surfaces smooth and flat.	(2)
	11	Surface dull, darkened, or stained. Gen. not "bright".	(1)	Mostly dull, but may have up to 30% bright surfaces.	(2)
	12	Assorted sizes tightly packed and/or overlapping.	(2)	Moderately packed with some overlapping.	(4)
	13	No change in sizes evident. Stable materials 80-100%.	(4)	Distribution shift slight. Stable materials 50-80%.	(8)
	14	Less than 5% of the bottom affected by scouring and deposition.	(6)	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	(12)
	15	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.	(1)	Common. Algal forms in low velocity & pool areas. Moss here too and swifter waters.	(2)
		EXCELLENT COLUMN TOTAL →		GOOD COLUMN TOTAL →	

Add values in each column and record in spaces below. Add column scores.

E.___ + G.___ + F.___ + P.___ = Total Reach Score.

Adjective ratings: E=Excellent, 39-30=Good, 77-114=Fair, 115+=Poor*

*(Scores above may be locally adjusted by Forest Hydrologist)

R1-Form 2300-5A Rev.1-75 Side 1.

INVENTORY DATA: (observed or assessed on this date) Side 2

Stream Width___ft.X Ave.Depth___ft.X Ave.Velocity___f/s=___Flow cfs

Reach Stream Turbidity Stream Sinuosity

Gradient___%, Order___, Level _____, Stage_____, Ratio _____,

Temperature Air____Water____, Others_____

°F or °C of:

	Key #	Stability Indicators by Classes FAIR		POOR	
Upper Banks	1	Bank slope gradient 40-60%.	(6)	Bank slope gradient 60%+.	(8)
	2	Moderate frequency & size, with some raw spots eroded by water during high flows.	(9)	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	(12)
	3	Present, volume and size are both increasing.	(6)	Moderate to heavy amounts, predominantly larger sizes.	(8)
	4	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	(9)	<50% density plus fewer species & less vigor indicate poor, discontinuous, and shallow root mass.	(12)
Lower Banks	5	Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.	(3)	Inadequate. Overbank flows common. W/D ratio > 25.	(4)
	6	20 to 40%, with most in the 3-6" diameter class.	(6)	< 20% rock fragments of gravel size, 1-3" or less.	(8)
	7	Moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling of pools.	(6)	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	(8)
	8	Significant. Cuts 12-24" high. Root mat overhange and sloughing evident.	(12)	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	(16)
	9	Moderate deposition of new gravel & coarse sand on old and some new bars.	(12)	Extensive deposits of predominantly fine particles. Accelerated bar development.	(16)
Bottom	10	Corners & edges well rounded in two dimensions.	(3)	Well rounded in all dimensions, surfaces smooth.	(4)
	11	Mixture, 50-50% dull and bright, a 10% le. 30-60%.	(3)	Predominately bright, 65%+, exposed or scoured surfaces.	(4)
	12	Mostly a loose assortment with no apparent overlap.	(6)	No packing evident. Loose assortment, easily moved.	(8)
	13	Moderate change in sizes. Stable materials 20-50%.	(12)	Marked distribution change. Stable materials 0-20%.	(16)
	14	30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	(18)	More than 50% of the bottom in a state of flux or change nearly yearlong.	(24)
	15	Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick	(3)	Perennial type scours or absent. Yellow-green, short term blooms may be present.	(4)
		FAIR COLUMN TOTAL →		POOR COLUMN TOTAL →	

Size Composition of Bottom Materials (Total to 100%)

1. Exposed bedrock.....___%
2. Large boulders, 3'+ Dia.....___%
3. Small boulders, 1-3'.....___%
4. Large rubble, 6"-12".....___%
5. Small rubble, 3"-6".....___%
6. Coarse gravel, 1"-3".....___%
7. Fine gravel, 0.1-1".....___%
8. Sand, silt, clay, muck..___%

Figure 1. U.S. Forest Service Stream Reach Inventory and Channel Stability Evaluation Form.

crossings, were noted by the observer equipped with the topographic maps and a tape recorder. Other habitat features such as stream pattern, bank slope characteristics, streambed material, debris quantity and spawning potential for cutthroat and bull trout were noted. A general overview of geomorphically similar sections (reaches) was also gained during the upstream flight. General location of reach breaks were based largely on changes in stream gradient. A return flight downstream at greater altitude and speed allowed the observer to establish actual reach breaks and confirm locations, while keeping flying time to a minimum. A mobile fuel source provided by a backup observer and a vehicle carrying 55 gallon fuel drums also reduced fuel consumption and flying time.

Tapes were transcribed in the office and stream features and reach breaks were added to the U.S.G.S. maps. A Helicopter Stream Survey Report (Figure 2) was compiled for each reach. Recorded information included a suggested survey section typifying the reach, information on stream features, reach characteristics and general comments. Length of the recommended survey section was based on total reach length. Completed helicopter survey forms and a field copy of the U.S.G.S. maps accompanied crews conducting ground surveys.

GROUND SURVEY

Before beginning ground surveys, an intensive one or two day training session was conducted to teach survey personnel the techniques and standarize each individual's perception of what constitutes each habitat variable classification. During this training session, replicate surveys were conducted by all field personnel in two person crews so that replication of survey results could be tested. If results from replicate surveys differed significantly, more discussion and training were used to ensure results obtained from different crews in the same reach were similar. It was advisable to repeat this replicate survey with all ground crews once during the field season to test the assumption that surveys were conducted in a similar manner.

Crews of two trained observers performed the ground survey for each reach. The crew confirmed helicopter observations of obstructions to fish passage and other important features in each reach. The top of form FMD-I (Figure 3) was completed upon arrival at the survey section. Stations where observers measured and rated habitat characteristics were selected by pacing a predetermined random distance along the stream channel. These random paces were listed on the bottom portion of form FMD-I (Figure 3). The following parameters were evaluated at 20 randomly located sites per km:

(1) flow character
(2) debris presence
(3) debris stability
(4) side channel occurrence
(5) split channel occurrence
(6) habitat unit (pool, riffle, run, pocketwater, cascade)

Aquatic habitat was further quantified at a variable number of transects

FORM: FMD-H

HELICOPTER STREAM SURVEY REPORT

Stream: _____ Reach No. _____ Stream kms: _____

Date: _____ Time: _____ Observer: _____

Suggested survey section - km ____ to km ____

Reach Characteristics

Upper bank slope: _____ Mass wasting potential: _____

Valley flat: _____ Pattern: _____

Flow characteristics: _____ Channel width: _____

Debris - channel: _____ Barriers - types: _____
floodplain: _____ locations: _____

Spawning potential - Bull trout: _____
Cutthroat: _____

Portion recommended for redd counts:

Bull trout - km _____ to km _____
Cutthroat - km _____ to km _____

General comments:

Stream features:

Figure 2. Helicopter Stream Survey report.

FORM FMD-1

Length of survey section _____
Start of survey: km_____
Stage: Dry L M H Flood
Turbidity: nil L M High
Confinement: Ent Conf Fr Oc Un N/A
Pattern: St Sin Ir IM Rm Tm
Valley flat:

Creek Name _____
Water Code:_____ Reach:_____
Survey personnel _____
Agency _____
Date:_____ Time:_____
Air Temp _____ Water temp.:_____
Weather _____
Photos _____
Flow _____ Loc _____

OFFICE

Bank: form _____ process _____
Debris: _____ % stable _____
Side chan _____ Split chan _____
Wet width _____ m Chan width _____ m
Floodplain Debris: N L M H
Flow char: P S R B T

SUBSTRATE		
Size Class	Streambed	Bank
Silt -detritus		
Sand (<2 mm)		
Sm. Gravel (2-6.4mm)		
Lg. Gravel (6.4-64mm)		
Cobble (64-256 mm)		
Boulder-bedrock (>256 mm)		

Reach length _____ Gradient_____
Reach location_____
Stream Order_____
Depth: Avg_____cm Max _____cm
Imbeddedness: 0-25 25-50 50-75 75-100
Compaction _____ D90 _____ cm
Genetic Material: _____

HABITAT UNIT	%
Pool	
Riffle	
Run	
Pocket water	
Cascade	

Pool Class	%
I	
II	
III	

Instream cover _____% Type: _____
Overhead cover _____% Type: _____

Vertical Stability - A ? D

_____m per pace

Pace No.	Transect No.	Flow Char.	DEBRIS Pres.	DEBRIS Abs.	DEBRIS Stable	DEBRIS Unstable	Side Chan.	Split Chan.	Habitat unit	Pool(I,II,III) Riffle Run	Pocket Water Cascade
30	1										
54											
177											
271	2										
428											
467											
540	3										
609											
632											
679	4										
774											
803											
858	5										
967											

Figure 3. Form FMD-I for general field and office data.

Pace No.	Transect No.	Flow Char.	DEBRIS Pres.	Abs.	Stable	Unstable	Side Chan.	Split Chan.	Feature Pool(I,II,III) Riffle Run Pocket Water Cascade

Significant features:

Pace No. km Description

Notes:

Figure 3. (Continued).

per km, depending on the level of precision desired. The following parameters were measured at one meter intervals or at a minimum of five equally spaced points across each transect:

(1) depth to nearest cm
(2) instream cover
(3) overhead cover
(4) two predominant substrate size classes

Visual estimates of substrate imbeddedness, compaction, D-90, percentages of each substrate size class, percentages of instream and bank cover and maximum depth were also made at each transect to attempt to quantify these subjective observations by using multiple observation points. Total wetted width and channel width were measured at each transect.

At every fifth transect the following features were noted:

(1) flood signs
(2) bank form
(3) bank process
(4) bank composition

This information along with any additional comments were recorded on field form FMD-J (Figure 4).

The Forest Service stability evaluation (Figure 1) was completed immediately following the habitat survey on each reach. When possible, stream discharge was also measured at this time. The office portion of form FMD-I (Figure 3), summarizing field measurements, was completed any convenient time after the survey.

DATA ENTRY AND ANALYSIS

Habitat data for each reach were coded on Montana Interagency Stream Fishery Resource Data Forms (Holton et al. 1981). These forms and instructions concerning their use are presented in Appendix B. Data from completed Interagency forms were keypunched and entered in the statewide data base administered through the Department of Fish, Wildlife and Parks in Helena. A dictionary was constructed enabling any physical, chemical or biological parameter available to be requested for a particular reach (Fraley et al. 1981). Use of the habitat evaluation methods and their applicability to fisheries and land management situations in the Flathead National Forest were described in Graham et al. (1982) and Fraley and Graham (1982).

Habitat survey transect data were entered into data files on the ICIS 850 computer located at the Montana Department of Fish, Wildlife and Parks Regional Headquarters, Kalispell, Montana. Computer programs (HABFST and SUMMAR) were developed to enter and summarize habitat information by survey section.

FMD-J

Creek: _____ Transect No.: 1-4 Date: _____ TEMP: Air: _____ Water: _____

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Depth:																
Substr:																
O.H. Cover:																
Instream Cover:																

Total Wetted Width: _____ Channel Width: _____ Feature: _____ Depth (Maximum): _____ VISUAL STREAMBED: Organic: _____; Fines: _____; Small Gravel: _____ Large Gravel: _____; Gobble: _____; Boulder _____

Imbededness: _____ Compaction: Nil L M H D-90: _____ cm VISUAL COVER: Instream: _____ Bank: _____

Comments: _____

Creek: _____ Transect No.: 5 Date: _____ TEMP: Air: _____ Water: _____

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Depth:																
Substr:																
O.H. Cover:																
Instream Cover:																

Total Wetted Width: _____ Channel Width: _____ Feature: _____ Depth (Maximum): _____ VISUAL STREAMBED: Organic: _____; Fines: _____; Small Gravel: _____ Large Gravel: _____; Gobble: _____; Boulder _____

Imbededness: _____ Compaction: Nil L M H D-90: _____ cm VISUAL COVER: Instream: _____ Bank: _____

FLOOD SIGNS: Type: _____ Ht.: _____ BANK: Form: _____ Proc.: _____ BANK MATERIAL: Organic _____% Fine: _____% Sm. grav.: _____% L. grav: _____% Cobb: _____% Boulder: _____%

Comments: _____

Figure 4. Field transect form FMD-J.

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APPENDIX A

Glossary of terminology used in stream habitat surveys.
Adapted from British Columbia Ministry of Environment,
Resource Analysis Branch.

PREFACE

This glossary is organized with definitions preceded by the year in which they were adopted. Evaluation of some parameters changed one or more times during the four years of study, therefore several definitions may be presented for certain terms.

Many of the parameters described are classified in abundance by Nil, Low, Moderate or High. Where not specifically defined (e.g. stage) these terms should have the following meanings:

Nil	the item is not present, or so seldom as to be irrelevant to any interpretation.
Low	the item is present, but only as a few scattered occurrences or in a single spot.
Moderate	the item occurs in several scattered locations or a few small concentrated zones.
High	the item is frequently present throughout the sample area (reach or point) as continuous cover or frequent zones of occurrence.

GLOSSARY

bank - (1979) the rising ground bordering a stream channel below the level of rooted vegetation and above the normal streambed; designated as right or left facing downstream. (See bank form and bank process). See also Figure 1.

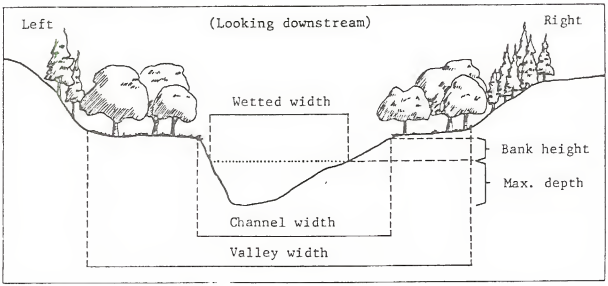


FIGURE 1. Stream Cross section

bank cover - (1982) refers only to percent overhang <1 m above water surface. Sample frequency - every transect.

bank form - (1979) the range of bank forms is arbitrarily separated into four classes which reflect the current state of river processes. Sample frequency - every fifth transect (Figure 2):

F (flat) - the river bed slopes gently to the beginning of rooted vegetation, frequently with overlapping bar deposits.

R (repose) - the bank is eroded at high water levels, but is at the angle of repose of the unconsolidated material (usually 34^{o} - 37^{o}).

S (steep) - the bank is nearly vertical, due to consolidation by cementation, compaction, root structure or some other agent.

U (undercut) - the bank has an undercut structure caused by erosion. When undercut banks are stabilized by vegetation this should be indicated in the comments.

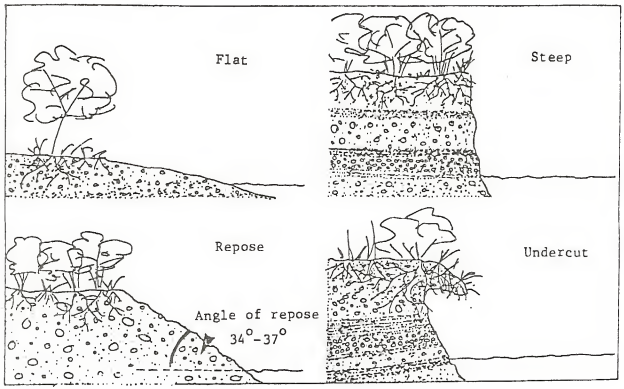


FIGURE 2. Bank Forms

bank process - (1979) the current fluvial process the bank is undergoing. Sample frequency - every fifth transect.

F (failing) - active erosion and slumping is taking place.

S (stable) - the bank is of rock, has very high root density, or is otherwise protected from erosion. Artificially stabilized banks should be noted in the comments.

A (aggrading) - continuous sediment deposition is taking place, causing the river channel to migrate away from the river bank. Common on the inside of meander bends where it may be accompanied by the presence of a range of early to late seral vegetation.

barrier - See Obstruction.

cascade - (1982) a habitat unit consisting of a series of small steps or falls.

channel - (1979) a natural or artificial waterway of perceptible extent which periodically or continuously contains moving water. It has definite bed and banks which normally confine the water, and which display evidence of fluvial processes (See channel width and Figure 1).

channel width - (1979) the width of the channel from rooted vegetation to rooted vegetation. Mean annual high water level should be used in the absence of vegetation. If measured by tape, the width should be given to the nearest 0.1 m (See Figure 1). Sample frequency - every transect.

cover - (1979) anything which projects over the water surface at the time of survey. It is divided into two arbitrary levels; crown cover (>1 m above water surface) and overhang cover (<1 m above water surface). Described in terms of the projected area of water surface covered (% of wetted surface area). Sample frequency - visual average for reach.

(1982) sheltered areas in a wetted stream channel where a trout can rest and hide in order to avoid the impact of the elements or enemies. Instream cover types include aquatic vegetation, logs, debris, large cobbles and boulders, and man-made structures. Overhead cover would include undercut banks, overhanging vegetation 1 m or less above the water surface (bank cover), overhanging understory and overhanging overstory canopy. Sample frequency - 1 m intervals or at a minimum of five equally spaced cells across each transect. Cover types were expressed in terms of percent based on presence/absence data for all transects in the reach. Cover types were coded as follows:

Cover Codes

Instream Type	Code No.	Overhead Type	Code No.
None	0	None	0
Aquatic vegetation	1	Undercut bank	1
Logs	2	Overhead (<1 m)	2
Debris } Below water	3	Understory (1-5 m)	3
Boulders } surface	4	Overstory (>5 m)	4
Logs	5		
Debris } Above water	6		
Boulders } surface	7		
Man-made structure	8		

- (1983) turbulence was added as an instream cover type. Logs, debris, and boulders above the water surface (instream cover code numbers 5,6 & 7) were deleted from the list of instream cover types and were recorded as overhead (<1 m) or understory (1-5 m) cover. Cover was recorded as being present only if it provided cover over at least 10% of the surface area of the cell being considered.

compaction - (1979) the relative looseness of bed material with respect to fluvial processes. Caused by sedimentation, mineralization, imbrication or material size. Indicated as nil, low, moderate or high as determined by the relative ease with which a boot can be worked into streambed material. Sample frequency - every transect.

confinement - (1979) the degree to which the river channel is limited in its lateral movement by terraces or valley walls (See Figure 3). Sample frequency - average for reach by visual and maps. The channel is either:

Ent - entrenched - the streambank is in continuous contact (coincident with) valley walls.

Conf - confined - in continuous or repeated contact at the outside of major meander bends.

Fr - frequently confined by the valley wall.

Oc - occasionally confined by the valley wall.

Un - unconfined - not touching the valley wall.

N/A - not applicable (e.g. where no valley wall exists).

debris (channel) - (1979) organic material (primarily logs, limbs, root masses) deposited within the channel; not just in the wetted stream channel at the time of survey. Debris is recorded as being present if it could provide trout cover over at least one tenth of the channel width at bankful flow.

(1982) described as present or absent at 20 sites per km.

debris (floodplain) - (1980) organic material (primarily logs, limbs, root masses) deposited within the floodplain at time of survey. Described as Nil, Low, Moderate or High. (See flood sign). Sample frequency - average for reach taken from helicopter sheets.

debris stability - (1979) debris in the stream channel that has a low probability of being moved out of the area during normal spring runoff. Stable debris is usually embedded in or attached to the streambed or bank and forms a part of the stream's morphologic character.

(1982) Sample frequency - 20 sites per km.

D-90 - (1979) the diameter of bed material which is larger than 90% of the remaining material. Measured by length of intermediate axis. See Figure 4. Sample frequency - every transect.

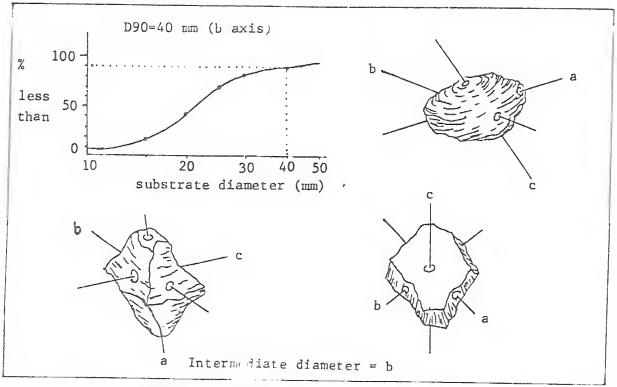
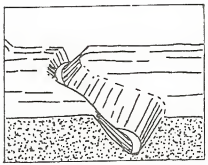
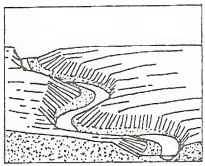


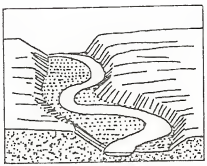
FIGURE 4. D-90 and Intermediate Axis



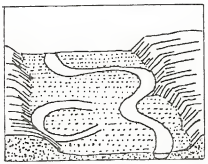
Entrenched



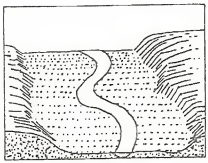
Confined



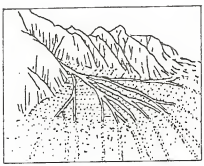
Frequently confined



Occasionally confined



Un-confined



Not applicable

FIGURE 3: Confinement

embeddedness (imbeddedness) - (1979) the degree of filling of the interstitial spaces of a gravel or rubble stream bottom with sand or fines. Estimated as 0 to 25%, 25 to 50% , 50 to 75%, or 75 to 100% embedded. Sample frequency - every transect.

- (1983) the extent to which the predominant-sized particles in the streambed are covered by fine materials (sand & silt). Embeddedness was coded as follows:

Embeddedness	Code No.
Dominant particle size group completely embedded in fines (or nearly so).	1
Three-fourths embedded	2
One-half embedded	3
One-fourth embedded	4
Unembedded	5

entrenchment - (1979) stream channel incision resulting from current fluvial processes. This represents the extreme case of stream confinement. (See confinement).

feature - (1979) a specific stream attribute worthy of note. Important stream features would include slumped banks, and barriers or obstructions (such as beaver dams, log jams, chutes, falls) that could possibly hinder upstream fish movement. The location, length and height of important features should be recorded.

flood signs - (1979) evidence of the height of historic flood water levels. Recorded are the "height" above water level at the time of survey and the "type" of evidence such as debris (D), flood channels or bank scour (E), soil profiles (P), mud deposited on trees (M), or historical information (H) such as might be found in newspaper files. Sample frequency - every fifth transect.

flow - (1979) discharge in cfs or cms. Method of measurement and meter type must be indicated. Sample frequency - flow during survey or average low flow.

flow character - (1979) the surface expression of the water that is determined by water velocity and bed material. Sample frequency - 20 sites per km. It is described at the time of survey as:

p - placid - tranquil, sluggish
s - swirling - eddies, boils, swirls
r - rolling - unbroken wave forms numerous
b - broken - standing waves are broken, rapids, numerous hydraulic jumps
t - tumbling - cascades, usually over large boulders or rock outcrops.

genetic material - (1979) materials are classified according to their mode of formation. Specific processes of erosion, transportion, deposition, mass wasting and weathering produce specific types of materials that are characterized chiefly by texture and surface expression. Subsurface layers are noted in a comment. Sample frequency - visual average for reach.

Descriptive terminology:

A Anthropogenic - man-made or man-modified materials; including those associated with mineral exploitation and waste disposal, and excluding archaelogical sites.

C Colluvial- product of mass wastage; materials that have reached their present position by direct, gravity-induced movement (i.e. no agent of transportation involved). Usually angular and poorly sorted.

E Eolian - materials transported and deposited by wind action. Usually silt or fine sand with thin cross-bedding.

F Fluvial - materials transported and deposited by streams and rivers. Usually rounded, sorted into horizontal layers, and poorly compacted.

I Ice - glacier ice.

L Lacustrine - sediments that have settled from suspension of bodies of standing fresh water or that have accumulated at their margins through wave action. May be fine textured with repetitive annual layers (varves).

M Morainal - the material transported beneath, beside, or within and in front of a glacier; deposited directly from the glacier and not modified by any intermediate agent. Usually poorly sorted and angular to sub-angular. May be highly compacted and have significant clay content.

O Organic - materials resulting from vegetative growth, decay and accumulation in and around closed basins or on gentle slopes where the rate of accumulation exceeds that of decay.

R Bedrock - rock outcrop and rock covered by a thin mantle (less than 10 cm) of consolidated materials.

S Saprolite - weathered bedrock, decomposed <u>in situ</u> principally by processes of chemical weathering.

V Volcanic - unconsolidated pyroclastic sediments that occur extensively at the land surface.

W Marine - sediments that have settled from suspension in salt or brackish water bodies or that have accumulated at their margins through shoreline processes such as wave action and longshore drift. Found in coastal areas below 125 m above sea level.

U Undifferentiated - layered sequence of more than three types of genetic material outcropping on a steep, erosional (scarp) slope.

gradient - (1979) Difference in elevation (m) from upper to lower reach breaks divided by length of reach (m) X 100. Calculated from a topographic map. Sample frequency - for entire reach.

habitat unit - (1979a) expression of streams hydrologic nature. Sample frequency - 20 sites per km. Broken into:

pool
riffle
run
glide

(1979b) pool
riffle
run

(1980) pool
riffle
run
pocketwater

(1982) pool
riffle
run
pocketwater
cascade

instream cover - (1982) See cover.

notes - (1979) comments should be made in regards to habitat suitability for spawning westslope cutthroat trout and bull trout; land use activities (logging, grazing, etc.) in the valley flat and proximity to streambanks; uniformity of habitat within reach; etc.

obstruction - (1979) any object or formation that may block or hinder waterflow and/or fish migration identified by helicopter and confirmed by ground crew. Various types are distinguished such as falls, cascade/chutes, beaver dams, culverts, velocity and man-made dams. Height, length and location should be recorded.

(1982) obstructions or barriers are classified as:

Type A: Complete barrier to all fish passage
Type B: Barrier to spawning bull trout
Type C: Possible barrier to all fish passage
Type D: Possible barrier to spawning bull trout.

pattern - (1979) the channel pattern of a reach described in terms of its relative meander curvature (See Figure 5). Sample frequency - average for reach by visual and maps. Classified as follows:

St straight - very little curvature within the reach.
Sin sinuous - slight curvature within a belt of less than approximately two channel widths.
Ir irregular - no repeatable pattern.
Im irregular meander - a repeated pattern is vaguely present in the channel plan. The angle between the channel and the general valley trend is less than 90°.
Rm regular meanders - characterized by a clearly repeated pattern.
Tm tortuous meanders - a more or less repeated pattern characterized by angles greater than 90°.

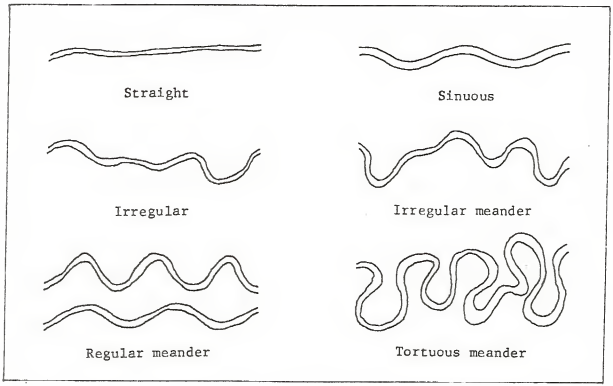


FIGURE 5. Channel Patterns

pocket water - (1980) a habitat unit - typically a run, whose flow is interrupted by boulders creating small turbulent pools or "pockets" which can provide cover for fish. Distinguished from cascade by the absence of small steps or falls.

pool - (1979) a habitat unit of low velocity and deep water relative to the main current.

pool classification - (1979) a classification scheme designed to indicate the value of a pool as fish habitat. Each pool is rated based on the size, depth, and cover. The total score is used to determine pool class. The scoring is as follows:

DEPTH RATING

Depth	Score
Over 3 feet	3
2-3 feet	2
Less than 2 feet	1

COVER RATING

Cover	Score
Abundant	3
Partial	2
Exposed	1

SIZE RATING
(measurement longest axis of pool)

Size	Score
Pool longer or wider than average width of stream	3
Pool as long or wide as average width of stream	2
Pool much shorter or narrower than average width of stream	1

TOTAL SCORE	POOL CLASS
8 or 9	I
7	II
5* or 6	III**

*A total score of 5 must include 2 points for depth and two points for cover.

**Pools that score less than Class III are recorded as "unclassified" or as "pocket water".

reach - (1979) a segment of a stream which has a distinct association of physical habitat characteristics. Gradient is an important factor in reach delineation. Streams are divided into reaches by aerial observer.

reach length - (1979) distance in km from lower to upper reach break. Measured on topographic map.

reach number - (1979) reaches are numbered sequentially upstream from the mouth (1,2,...n).

riffle - (1979) a habitat unit with shallow, fast moving water where the surface is turbulent and broken.

run - (1979) a habitat unit of medium velocity water with surface not turbulent to the extent of being broken. Intermediate between pool and riffle.

scour - (1979) substrate size, angularity and brightness indicate amount of scour or deposition along channel bottom. Described as Nil, Low, Moderate or High. Sample frequency - visual average for reach.

serial number - (1981) this number will be controlled by regional or state office or agency entering information.

side channel - (1979) a channel connected to the main channel that is usually less than one fourth of the average main channel width. Side channels typically have lower velocity flows (frequently placid) and smaller substrate (small gravel, fines, and detritus) than does the main channel. Described as present or absent at 20 sites per km.

split channel - (1982) channel divisions that do not differ significantly from the main channel in terms of current velocity or substrate type. Described as present or absent at 20 sites per km.

stage - (1979) the relative water level at the time of survey inferred from evidence of flow in bank and bed. Sample frequency - visual average for reach. The categories usedare dry, low, moderate, high and flood:

Dry - water not present or only as unconnected pools.
Low - water flowing as thread(s) within the channel; most bed material exposed.
Moderate - water flowing throughout the normal bed and in contact with lower portions of banks. Some bars are exposed; sand and small gravel sized bed material is in motion.
High - water flowing throughout the normal bed and in contact with middle to upper portions of banks; most bars are submerged; gravel and cobble. Sized bed material is in motion.
Flood - water bank full or over banks and into floodplain; maximum rates of bed material transport.

stability rating - (1980) nine ratings of bank stability combined with six ratings of bed stability for a stream reach. U.S. Forest Service stability evaluation field forms were used. Sample frequency - average for reach.

stream order - (1979) a number assigned to a stream based on its location in the drainage. Any unforked channel which appears on USGS maps is a first order drainage. Two first order streams meet to form a second order stream, and so on.

substrate composition - (1979) the assemblage of sizes of material in banks and bed. Sample frequency - every transect. Described according to the following:

	Code
Organic - material derived from animals or vegetation.	1
Fines - < 2.0 mm	2
Gravel - small - 2-16 mm; large - 16-64 mm	3,4
Cobble - 64-256 mm	5
Boulders - > 256 mm	6
Bedrock	

- (1982) the dominant and subdominant substrate types were recorded for each cell at 1 m intervals (or at a minimum of five equally spaced cells) across each transect. The percent composition of each substrate size class within the stream reach was calculated as the number of occurrences of a particular size class as either a dominant or subdominant type, divided by two times the number of measurement cells.

turbidity - (1979) described as Nil, Low, Moderate or High. Sample frequency - visual average for reach.

valley:channel ratio - (1979) $\frac{\text{mean valley width}}{\text{mean channel width}}$ Sample frequency - average for reach.

valley flat - (1979) the area of a valley bottom which may flood, including low terraces. Relic terraces which cannot be flooded by the present river are excluded from the valley flat. See Figure 6. Estimated mean width by aerial observer or from USGS maps.

valley wall - (1979) the remainder of the valley slope above the valley flat and relic terraces. In some cases such as on fans or deltas, there may be no valley wall. See Figure 6.

vertical stability - (1979) an indication of the net effect over a long time period of processes of deposition or scour of the streambed. Described as degrading (Deg), aggrading (Agr) or not obvious (?). Sample frequency - visual average for reach.

water chemistry - (1981) chemical parameters and ratings, optional.

water code - State of Montana Department of Fish, Wildlife and Parks code number for stream in question.

wetted width - the width of water surface at the point sample cross-section. Sample frequency - every transect.

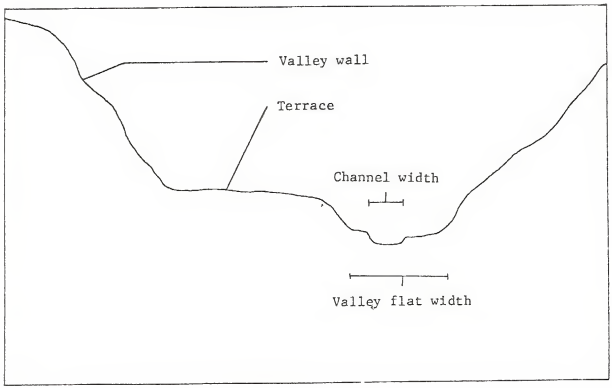


FIGURE 6. Valley Profile

APPENDIX B

Data entry format and explanation for the Interagency Stream Fishery Data Input Form (for cards 1-38 Format, instructions and example forms for additional cards 30 through 38).

INTERAGENCY STREAM FISHERY DATA INPUT
FORM INSTRUCTIONS FOR DATA ENTRY CARDS 1-22

CARD 1:

Serial Number: This number will be controlled by regional or state office or agency entering information.

State: The code for Montana is 30.

Hydrologic Unit Code: This entry designates the drainage. Regional and state office of each agency have these codes.

Stream Order: A numerical class identification assigned to a tributary based on its location in the drainage. Two first order streams meet to form a second order stream, etc.

State Water Code and Water Type: State water code and water type are obtained from a list furnished by the Montana Department of Fish, Wildlife and Parks. Stream water type codes are 01 to 19, with 19 being a stream unable to sustain a population of fish.

Reach: Portion of a stream with a distinct association of physical habitat characteristics. Gradient is the major factor in reach delineation.

Reach Number: The reaches are numbered consecutively from the mouth, up the stream.

CARD 2 AND 3:

Reach Boundaries: Brief description of upper and lower boundaries and map coordinates for these boundaries.

Elevation: Upper and lower elevation of reach boundaries in meters.

Average Wetted Width: Average of measurements from one water's edge to the other, taken at random intervals within the habitat section.

Tributary To: USGS map name of stream or river into which the study stream converges.

County: All Flathead County streams are 029.

CARD 5:

Fish and Game Region: All Flathead County streams are in Region One.

Percent Pocket Water: A series of small pools that do not classify as pools individually, but in combination create fish habitat. Pocket waters are usually found in boulder or cascade areas.

Ingress: Legal availability of public access to the stream.

CARD 8:

Flow During Survey: The instream flow (m^3/sec) during the survey and the date of observation.

Normal Low Flow: Lowest flow expected during an average year from past records or as can be estimated. Note: This is not the historic low flow.

Valley Flat: The area of a valley bottom which may flood, including low terraces. Relic terraces which cannot be flooded by the present river are excluded from the valley flat.

Channel Width: The width of the channel from rooted vegetation to rooted vegetation.

Average Maximum Pool Depth: The maximum depth measured in the deepest pool in the habitat section.

Gradient (%): Difference in elevation (meters) from upper to lower end of reach / Length of reach (meters)

This is usually measured with a clinometer or is calculated from a topographic map.

Pool-Run-Riffle Ratio: The estimated percent of each type, for a portion of the stream at low water. In combination with pocket water, equals 100%.

Pool - Usually deeper, quiet water, although pools may be at the base of falls.

Run - Moderately moving water with the surface not turbulent to the extent of being broken. Intermediate between pool and riffle.

Riffle - Shallow, fast moving water where the surface is turbulent and broken.

CARD 9 AND 10:

Bottom Type: Entered under Run. Percent make-up of bottom substrate (the bed material).

Average Peak Water Temperature: The highest water temperature measured during the summer.

Spring Creek: A spring creek or spring stream is identified by its fairly constant temperature, flow and clear water. Watercress will often be present.

Affected by Lake: When lake or impoundment significantly affects water temperature, flow pattern, fish food, or fish runs within the reach or

stream.

Inundated by Beaver Ponds: The percent of the reach length presently impounded by beaver ponds is entered.

D-90: The diameter of bed material which is larger than 90 percent of the remaining material. Measured by length of intermediate axis.

Total Alkalinity and Specific Conductance: Alkalinity and conductivity values are measured at the lower end of individual drainages during the low flow period.

Floating: Recreational use by boaters.

Special Value: Importance as a trout recruitment stream.

CARD 11:

Channel Stability Rating Elements: Nine ratings of bank stability combined with six ratings of bed material for a stream reach. U.S. Forest Service stability evaluation field forms were used.

Pool Classes: The percentage of the pools in the reach in each pool class. Total = 100 percent. Pool classes are determined as follows:

Size: Measurements refer to the longest axis of the intersected pool.

3 - pool larger or wider than average width of stream
2 - pool as wide or long as average stream width
1 - pool much shorter and narrower than average stream width.

Depth Ratings	Cover Ratings
3 - Over 3 feet	3 - Abundant cover
2 - 2-3 feet	2 - Partial cover
1 - Under 2 feet	1 - Exposed

Total Ratings	Pool Class
8-9	1
7	2
5-6*	3
4-5	4
3	5

*Sum of 5 must include 2 for depth and 2 for cover.

Habitat Value for Fishes of Special Concern: A judgement value of habitat for spawning and production of westslope cutthroat.

Fish Population: List of game fish species present, their abundance and dominant use.

CARD 19:

Imbeddedness: The filling of the interstitial spaces of a gravel or rubble stream bottom with sand or fines.

Habitat Trend: All man-caused activities in or adjacent to the stream as well as dynamic natural processes.

Esthetic: Description of the pristine qualities of the reach.

CARD 20:

Channel Alterations: Cause, type, and length of artificial and natural changes occurring in the stream channel.

Bank Encroachment: Description of structure or activities that interfere with natural stream or floodplain hydraulics.

CARD 21:

Data Source: Month, year, field person, and agency to be contacted concerning data and agency.

CARD 22:

Information on the reach not contained on other cards.

ADDITIONAL INFORMATION:

Parameters were rated based on the following criteria:

1-3 means the data rated were based on judgement estimates.

4-6 means the data rated were based on limited measurements.

7-9 means the data rated were based on extensive measurements.

INTERAGENCY STREAM FISHERY DATA INPUT
FORM INSTRUCTIONS FOR DATA ENTRY CARDS 30-38

Cards 30-35 are optional, but any module that has entries must be complete, i.e., species (codes) and densities must be filled out.

CARD 30 - POOLS

Column 6-7: Method of estimating (see code sheets on page B8 for method abbreviations)

Column 8: Rating, enter 1-9

Column 9-11: Enter species code (enter 3 digit number) (012)

Columns 12-27: Enter density (0-999.9) per 100 m^2 for each age class

Columns 28-30: Enter species code (005)

Columns 31-46: Enter densities (0-999.9) per 100 m^2 for each age class

Columns 47-49: Species code (085)

Columns 50-57: Densities (0-999.9) per 100 m^2

If a species is not present, leave species code and density columns blank.

CARD 31 - 34 - RUNS, RIFFLES, POCKET WATER, COMBINED FEATURES

Same as Card 30

CARD 35

Same as Card 30 except enter Biomass (g/100 m^2) (0-999.9) instead of density.

CARD 36

Option, but any module that has entries must be complete, i.e., number, density, year and rating must be filled out.

Columns 6-8: Number of bull trout redds in reach, enter 0-999

Columns 9-11: Density of redds (no/km) (0-99.9)

Columns 12-13: Year of redd survey (1950 to 1980)

Columns 14: Rating 1-9

Sequence repeated through column 41.

CARD 37 - ADDITIONAL PHYSICAL [illegible] TRAT DATA

Columns 6-8: Average depth (0-999 cm)

Column 9: Rating (1-9)

Columns 10-11: Percent cover, overhang (0-99 or blank)

Columns 12-13: Percent canopy (0-99 or blank)

Column 14: Rating (1-9)

Columns 15-17: Wetted cross sectional area (m^2) .1-99.9

Column 18: Rating (1-9)

Columns 12-25: Drainage area (1-999999.9 or blank)

Column 26: Rating (1-9)

Column 27: Barrier Type (see code sheet for abbreviations)

Columns 28-31: Barriers (0-999.9 or blank)

Column 32: Rating (1-9)

Columns 33-42: Percent cover in features (0-99, or blank)

Column 43: Rating (1-9)

Columns 44-46: Blank

Columns 47-48: Flow characteristics (see code sheet for abbreviations, Alpha code - dominant in Col. 48)

Column 49: Blank

Columns 50-51: Valley - channel ratio (1-99)

Column 52: Rating (1-9)

Column 53: Confinement (see code abbreviations)

Column 54: Pattern (see code abbreviations)

Column 55: Floodplain debris - N L M H

Column 56: Channel debris - N L M H

Columns 57-59: Percent of stable debris (0-100)

Column 60: Rating (1-9)

Column 61: Bank Form (see code abbreviations)

Column 62: Bank Process (see code abbreviations)

Column 63: Type of Genetic Material (see code abbreviations)

Column 64: Rating (1-9)

CARD 38 - OPTIONAL

Chemical parameters and ratings, optional, all can be blank

Lines 6-9: Total Carbon (.01-9.99) Rating 1-9

Lines 10-13: Total Phosphorous (.001-.999) Rating 1-9

Lines 14-17: No_3 - (.01-9.99) Rating 1-9

Lines 18-21: SO_4 - 2 (.1-99.9) Rating 1-9

Lines 22-25: Na^+ (.1-99.9) Rating 1-9

Lines 26-29: K^+ (.01-9.99) Rating 1-9

Lines 30-33: Ca^{+2} (.1-99.9) Rating 1-9

Lines 34-37: Mg^{+2} (.1-99.9) Rating 1-9

Line 38: Turbidity - N L M H, (Nil, Low, Moderate, High)

CODE ABBREVIATIONS

METHOD OF OBTAINING FISH ABUNDANCE INFORMATION

A two letter code was used to identify the method for obtaining fish information. The first letter identifies the Method used to collect the information and the second letter identifies the Estimator used.

1st Letter	METHOD	2nd Letter	ESTIMATOR
	Electrofishing		
B:	Boat electrofishing with boom	T:	Two-pass
M:	Boat electrofishing with mobile anode	P:	Peterson mark-recapture
S:	Bank electrofishing	Z:	Zippin
P:	Backpack electrofishing	S:	Schnable mark-recapture
		C:	Catch per unit effort
		N:	Total catch
	Observation	U:	Unknown
		D:	Density
U:	Underwater observation (snorkel)		
I:	Above water observation		
	Nets		
W:	Weirs		
J:	Trammel net		
L:	Trap-type net without leads		
N:	Trap-type net with leads		
O:	Purse seine		
Q:	Beach seine		
T:	Trawl		
V:	Vertical gill net		
F:	Floating gill net		
G:	Sinking gill net		
D:	Drift net		
	Other		
K:	Creel		
H:	Hydroacoustic		
C:	Chemical		
E:	Explosives		
R:	Dewatering		
Z:	Hand capture		
A:	Angling		

FLOW CHARACTERISTICS

P:	Placid - Tranquil, Sluggish
S:	Swirling - Eddies, Boils, Swirls
R:	Rolling - Unbroken wave forms numerous
B:	Broken - Standing waves are broken, rapids, numerous hydraulic jumps
T:	Tumbling - Cascades, usually over large boulders or rock outcrops

BARRIER TYPES

A:	Complete barrier to all fish passage
B:	Barrier to spawning bulls
C:	Possible barrier to all fish passage
D:	Possible barrier to spawning bulls

CONFINEMENT

Confinement (R) - the degree to which the river channel is limited in its lateral movement by terraces or valley walls. The channel is either:

E:	Ent	Entrenched - The streambank is in continuous contact (coincident with) valley walls.
C:	Conf	Confined - In continuous or repeated contact at the outside of major meander bends.
F:	Fr	Frequently confined by the valley wall.
X:	Oc	Occasionally confined by the valley wall.
U:	Un	Unconfined - not touching the valley wall.
N:	N/A	Not applicable (e.g. where no valley wall exists).

Confinement Classification

Entrenched

Confined

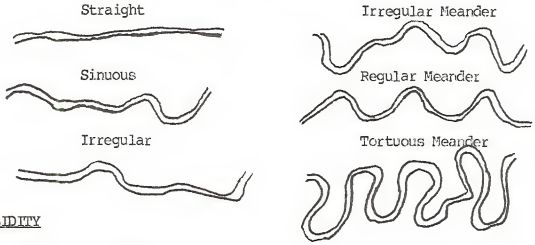
PATTERN

Pattern (R) - The channel pattern for the reach is described in terms of curvature. The channel is either:

S:	St	Straight - Very little curvature within the reach.
N:	Sin	Sinuous - Slight curvature within a belt of less than approximately two channel widths.

P:	Ir	Irregular - No repeatable pattern.
C:	Im	Irregular Meander - A repeated pattern is vaguely present in the channel plan. The angle between the channel and the general valley trend is less than 90°.
R:	Rm	Regular Meanders - Characterized by a clearly repeated pattern.
T:	Tm	Tortuous Meanders - A more or less repeated pattern characterized by angles greater than 90°.

Typical Meander Patterns



TURBIDITY

H:	High
L:	Low
M:	Moderate
N:	Nil

BANK PROCESS (P)

The current fluvial process the bank is undergoing.

F:	Failing - Active erosion and slumping is taking place.
S:	Stable - The bank is composed of rock and has a very high root density, or is otherwise protected from erosion. Artificially stabilized banks should be noted in the comments.
A:	Aggrading - Continuous sediment deposition is taking place, causing the river channel to migrate away from the river bank. Common on the inside of meander bends where it may be accompanied by the presence of a range of early to late seral vegetation.

BANK FORM

The range of bank forms is arbitrarily separated into four classes which reflect the current state of river processes. These are:

F: Flat - The riverbed slopes gently to the beginning of rooted vegetation, frequently with overlapping bar deposits.

R: Repose - The bank is eroded at high water levels, but is at the angle of repose of the unconsolidated material (usually 34^{o} - 37^{o}).

S: Steep - The bank is nearly vertical, due to consolidation by cementation, compaction, root structure, or some other agent.

U: Undercut - The bank has an undercut structure caused by erosion. When undercut banks are stabilized by vegetation this should be indicated in the comments.

GENETIC MATERIALS (P)

Materials are classified according to their mode of formation. Specific processes of erosion, transportation, deposition, mass wasting and weathering produce specific types of materials that are characterized chiefly by texture and surface expression. For added detail, consult the Terrain Classification Manual (ELUC - Sec. 1976). Subsurface layers are noted in a comment. Descriptive terminology:

A: Anthropogenic - Man-made or man-modified materials; including those associated with mineral exploitation and waste disposal, and excluding archaeological sites.

C: Colluvial - Product of mass wastage; minerals that have reached their present position by direct, gravity-induced movement (i.e. no agent of transportation involved). Usually angular and poorly sorted.

E: Eolian - Materials transported and deposited by wind action. Usually silt or fine sand with thin cross-bedding.

F: Fluvial - Materials transported and deposited by streams and rivers. Usually rounded, sorted into horizontal layers, and poorly compacted.

K: Ice - Glacier ice.

L: Lacustrine - Sediments that have settled from suspension in bodies of standing fresh water or that have accumulated at their margins through wave action. May be fine textured with repetitive annual layers (varves).

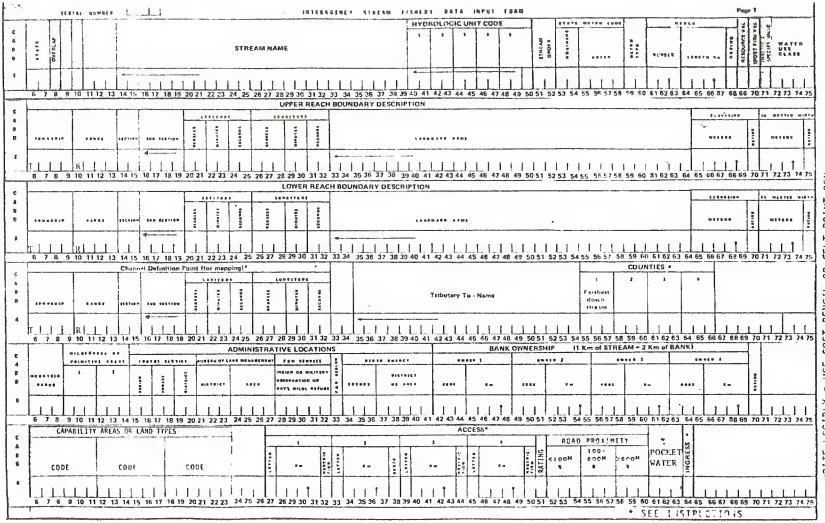


Figure 1. Interagency Stream Fishery Input Data Form.

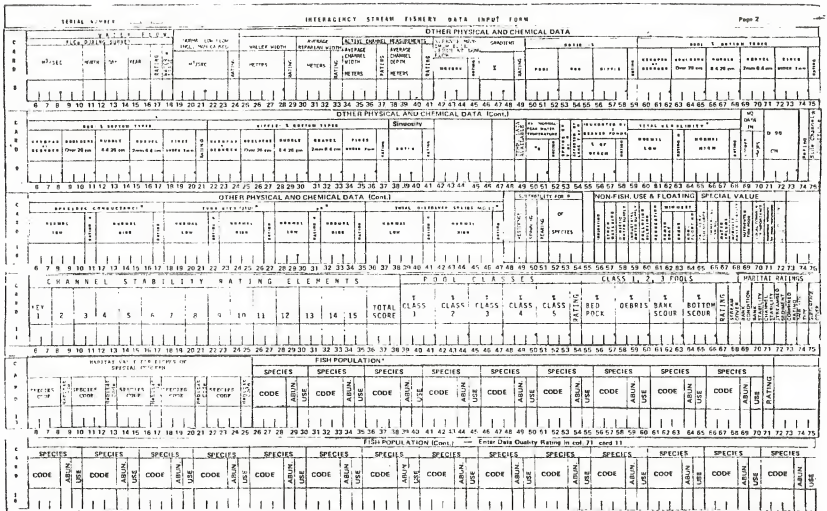


Figure 1. (Continued).

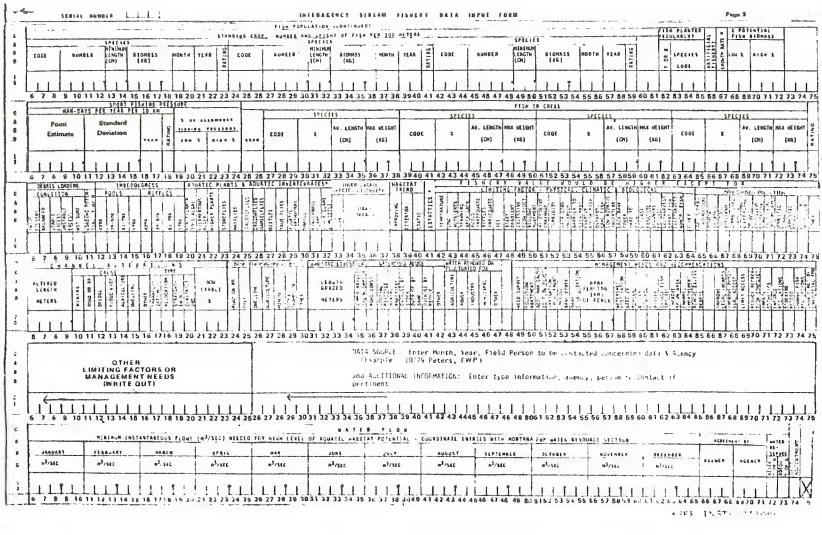


Figure 1. (Continued).

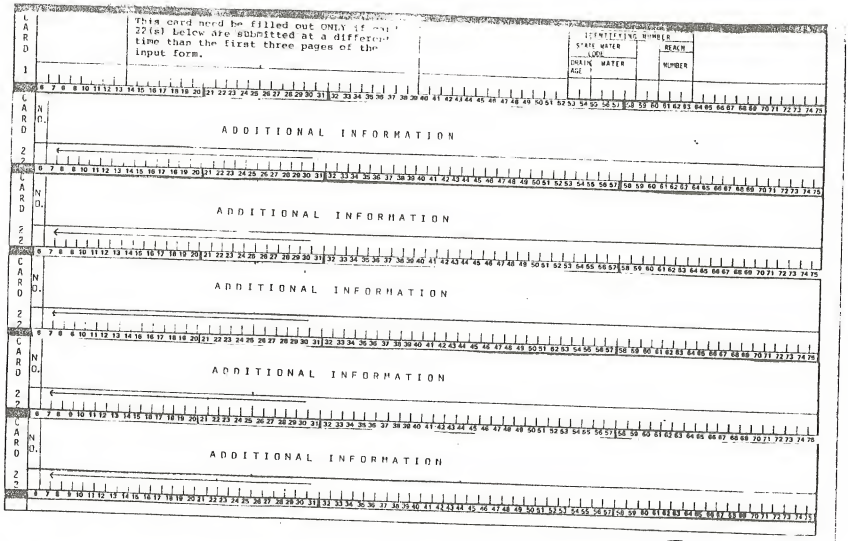


Figure 1. (Continued).

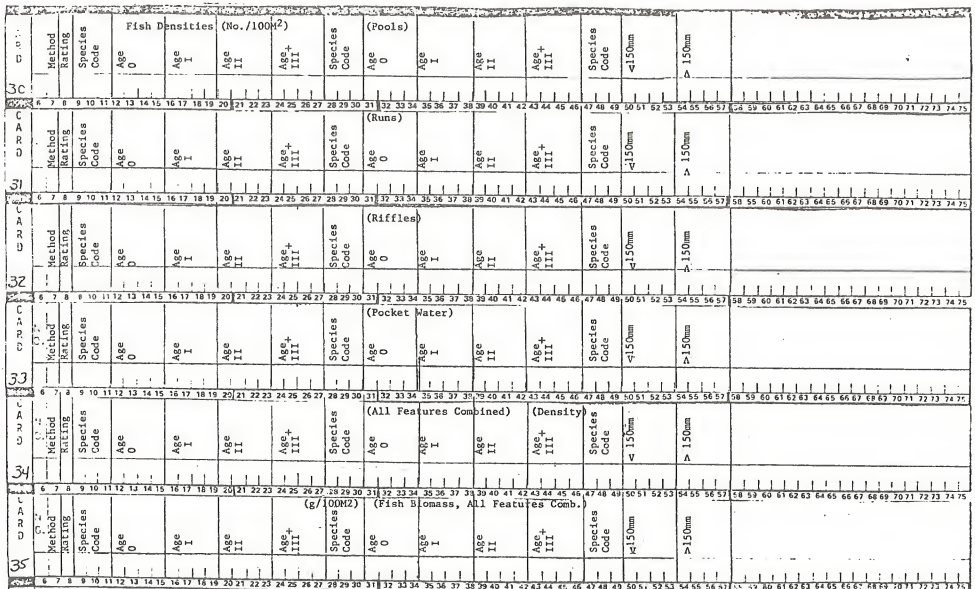


Figure 1. (Continued).

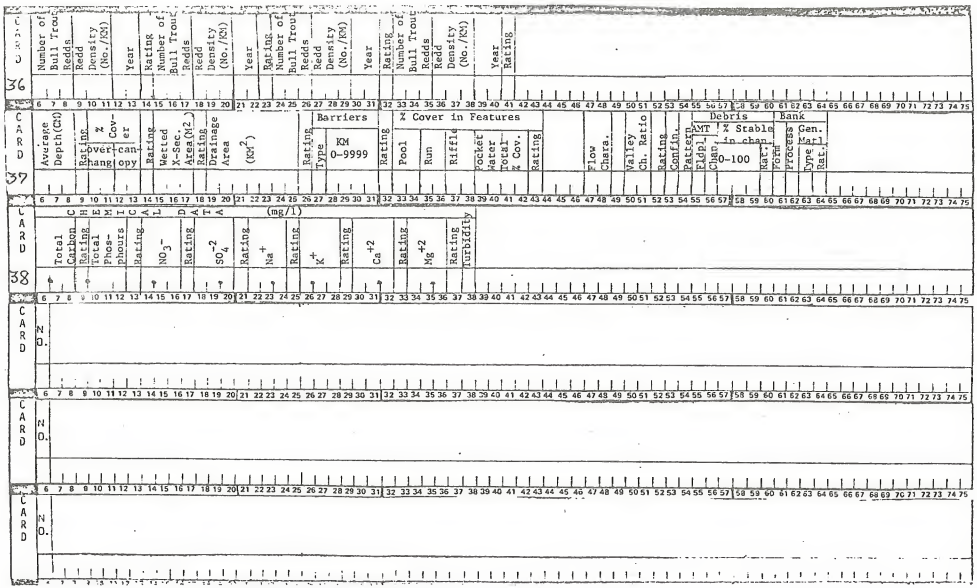


Figure 1. (Continued).